CMI MUSIC KEYBOARDS, #MC004 & #MC005

SERVICE MANUAL

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Revision 2.1

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1. INTRODUCTION

The CMI has provision for one Master keyboard and an optional Slave keyboard which operates in parallel with the Master. The CMI mainframe has only one keyboard input port, to which is connected the Master keyboard. The Slave keyboard, Alpha-numeric keyboard, and other attachments such as pedal controls, all connect to the Master keyboard. The latter contains an intelligent communications interface which monitors all attached devices and routes information from them through the single channel to the CMI.

In addition to the piano type music keyboard, the Master keyboard provides three slider pot analog controls and two switch controls (one momentary on, the other on/off) with lamp indicators whose purpose may be defined by the user by means of the CMI system software. A 12 character LED alpha-numeric display and 16 switch keypad constitutes a simple user interface to the mainframe so that during a live performance, operations such as loading voices may be performed directly from the Master keyboard.

The Slave keyboard serves only as an extra music keyboard and contains none of the extra facilities of the Master keyboard.

Related Documents: The following drawings are either referred to directly in this manual or will be of use in servicing the CMI music keyboards -

Exploded diagrams	DMC004 Master Keyboard
	DMC004B Master Keyboard with cover
	DMC015 Keyboard switches subassembly
	DMC005 Slave Keyboard
Drawing	DMC004C Bottom panel screw positions
Schematic Diagrams	MC004-01 Master keyboard wiring
	CMI10-00 Master controller to CMI10-02
	CMI11-01 Switch module
	CMI12-01 Display/keypad
	CMI14 Slave keyboard interface.

1.1 OPERATING PRINCIPLES

Control over all keyboard functions is centralised upon the CMI-10 Keyboard Controller which is located within the Master Keyboard. Keyboard scanning, of both master and slave keyboards, is accomplished by analog multiplexing of the voltages on all key switches. The key switch mechanism consists of two brass buss bars running the full length of the keyboard which are supplied with +5 and -5 volts, and a delicate spring contact on each key which is allowed to move between the two buss bars as the key is pressed. By measuring the time it takes the spring contact voltage to change from -5V to +5V, the velocity with which a key is pressed may be calculated.

The analog multiplexing is performed by the CMI-11 switch modules, each of which has provision for 24 or 25 spring contacts. Each module provides one analog output which is the state of the contact currently addressed by the select lines from the controller, and each keyboard contains three modules. Six analog comparators (three for the master and three for the slave) on the master controller receive these analog signals and determine the state of the currently addressed key.

The user keypad and off/on switches are scanned in the same way although the multiplexed states are read directly as a digital signal.

The wipers of the three slider controls on the master keyboard and three plug-in pedal pots are similarly multiplexed and fed to a single analog to digital converter on the master keyboard controller. A change detected in any analog level read by this converter is reported to the CMI provided that change is greater than a certain tolerance set by a 6-pole DIL switch.

All information reflecting the state of the master and slave keyboards, and attached pedal controls plus characters received from the alpha-numeric keyboard are sent to the CMI through a single serial communications channel. User information received from the CMI through the same link is displayed on the LED display. The display modules accept ASCII characters directly from the keyboard controller.

2. KEYBOARD DIS ASSEMBLY AND REASSEMBLY

2.1 MASTER KEYBOARD DISASSEMBLY

2.1.1 Removal of Wooden cover.
(Refer to drawings DMC-004C and DMC-004B)

(1) Switch off CMI power and remove all cable connections to the keyboard.

(2) Place keyboard upside-down on a soft surface.

(3) Remove the six screws marked "A" and the five screws marked "B" on the drawing DMC-004C from the bottom panel of the keyboard. Do not remove any screws other than these from the bottom panel at this stage.

(4) Return the keyboard right way up and remove the five back panel screws attaching the wooden cover to the panel, marked "C" on DMC-004C.

(5) Lift the cover from the rear about 5 cm. then slide the cover forward while continuing to raise the rear as illustrated in Fig 2.1.

With the cover off, the CMI-10 Keyboard Controller circuit module may now be observed, along with the wiring from the rear panel connections to the module. To remove the module, follow steps 6-9.

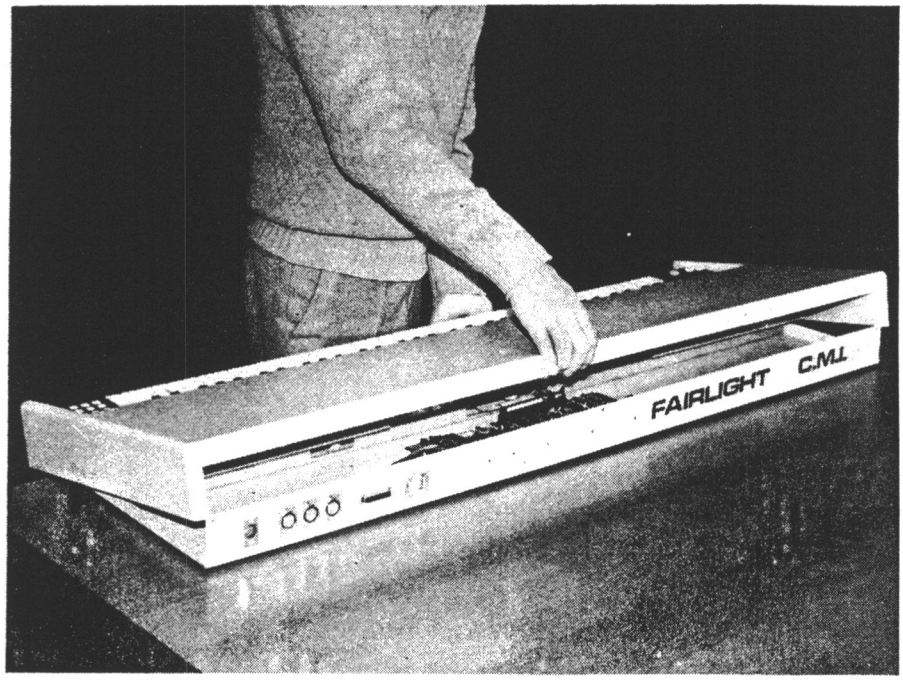


FIGURE 2.1

2.1.2 Removal of CMI-10 Keyboard Controller
(Refer to drawing DMC-004)

(6) Remove all cable connections to the CMI-10 module.

(7) Unscrew three nuts and bolts attaching the CMI-10's heatsink to the back panel.

(8) Six plastic standoffs secure the module to the base of the keyboard. With a small screwdriver, press the catch of each standoff while gently prising the module up.

(9) Lift the module off the standoffs.

2.1.3 Access to Keyboard Switch Mechanism
(Refer to drawings DMC-004C and DMC-015)

(10) Slide the keyboard forward so the five screws marked "D" in drawing DMC004C may be accessed from underneath. Remove these screws to release the retaining strip which secures the keyboard assembly to the bottom panel.

(11) The entire key assembly may now be swung up on its own hinges by lifting from underneath the keys. Support the assembly from behind on a piece of soft foam to avoid scratching the keys.

At this point the three CMI-11 switch modules may be viewed with the spring switch contacts gently stretched across the brass -5V buss bar and engaged in the plastic "keyhole grips" extending from underneath each key. Each grip has two keyholes: the spring contact should always be engaged with the lower one (closest to the underside of the key).

2.1.4 Removal of CMI-11 switch modules
(Refer to drawing DMC-015)

The following steps should be followed for each module to be removed:

(12) Remove the 10-way cable plug from its socket.
CAUTION: This cable should never be plugged or unplugged with the keyboard power applied or damage will result to the switch module circuitry.

(13) Using tweezers or fine pliers, gently grip each spring switch contact and stretch it just enough to release it from its keyhole catch. Tuck it down underneath the lower brass buss supply bar (-5V).

(14) Use a 6BA nut driver to remove the 9 nuts and star washers securing the switch module to the underside of the key assembly.

(15) Unscrew the 3 screws which pass through the buss bar support blocks to the underside of the key assembly.

(16) Lift the module off its supports.

2. KEYBOARD DIS ASSEMBLY AND REASSEMBLY (continued)

2.1.5 Removal of Control Panel and Display/Keypad
(Refer to drawing DMC-004)

(17) Slide the keyboard forward again as in step 10, and remove the four screws numbered 31 and 32 on the left in drawing DMC004 for the control panel, and/or the corresponding screws on the right for the display/keypad.

(18) Lower the keyboard and remove the 20-way flat cable from the display/keypad or release from its cable clips the 10-way ribbon cable leading from the CMI-10 module to the control panel. This cable is attached to the control panel.

(19) Lift the desired assembly out.

2.2 MASTER KEYBOARD REASSEMBLY

Reassembly of the Master keyboard is essentially a matter of reversing the procedures of Section 2.1. Care should be exercised while replacing the CMI-11 switch modules not to damage the delicate spring switch contacts. Tighten the nine nuts and three buss bar support screws evenly to ensure the module is not warped or distorted in any way and that the buss bars are not bent.

2.3 SLAVE KEYBOARD DISASSEMBLY AND REASSEMBLY

To remove the wooden cover and the CMI-11 switch modules from a slave keyboard, follow the same procedures as specified for the master keyboard in sections 2.1.1 and 2.1.3 respectively.

2.3.1 Removal of CMI-14 Slave Interface
(Refer to drawing DMC-005)

(1) With CMI power off, remove the flat cable connecting the master and slave keyboards, if not already done.
CAUTION: Always turn off CMI power to the master keyboard before connecting or disconnecting the external cable between the master and slave. Omission to do this will cause damage to the switch modules in the slave keyboard.

(2) The CMI-14 module is item 7 on DMC-005. Release the 25-way flat cable leading to the CMI-11 switch modules (item 8).

The same caution applies to this cable as to the external cable.

(3) Remove the three screws marked 13 which secure the module to the back panel of the slave keyboard.

Reassembly of the slave keyboard is the reverse of the disassembly procedures.

3.1 FAILURE OF MASTER KEYBOARD TO POWER-UP

Successful power-on sequence of the Keyboard Controller is indicated by the control panel switch lights flashing on for approximately 1 second, off for another second, then on again. A "- POWER ON -" message is then written to the LED display. If this does not occur and the CMI does not respond when the keyboard is played or the keypad operated, follow the procedure below.

(1) Check that all power supplies (+10V, +20V and -20V) are present on the Music Keyboard cable from the CMI. Refer to drawing MC004-01. If not, check CMI fuses, the Cannon connector on the back panel of the keyboard, and the cable itself.

(2) Remove the cover of the keyboard according to section 2.1.1.

(3) Ensure all cables are firmly connected and that the correct power supplies are present on the six pin Utilux connector to the CMI-10 Keyboard Controller. If not, look for the faulty connection between the back panel sockets and the CMI-10, referring to drawing MC004-01.

(4) Check that both DIL switches on the CMI-10 are set correctly. SW3 (4-way) should have switches 2 and 3 only closed, SW4 (6-way) should have switches 3 and 4 only closed. Refer to sections 4.1.1 and 4.1.3.

(5) Verify the voltages on each power supply regulator output on the CMI-10. Refer to section 4.3.1.

(6) Check that the power-on restart circuitry holds the processor in reset for approximately 0.4 secs. Refer to section 4.1.1.

(7) Check that the processor crystal is operating and that the processor ø2 output signal is present.

(8) Check that the processor is not receiving spurious interrupts due to a faulty SW3. Refer section 4.1.1

(9) Establish whether the controller is running its program by examining the VMA, data and address lines, and checking peripherals which are accessed in the processor idle loop (refer to section 4.4). If it is, then the controller is powering up but a major I/O problem is preventing all normal indications of this. Otherwise, a fault in the processor itself, the address decoding system, the ROMs or RAM is causing the controller to crash. In both cases, carefully check each of the functions described in section 4 to isolate the fault.

3. TROUBLE SHOOTING (continued)

3.2 INDIVIDUAL KEY FAILURE (Master and Slave)

The failure of a single key to operate will usually be caused by a mechanical problem in the spring switch contact mechanism. Remove the cover of the keyboard according to section 2.1.1 and hinge the key assembly up as described in section 2.1.3.

Common causes of failure are damaged, loose or dirty spring contacts, or inadequate contact between the spring and the brass buss bars.

3.3 FAILURE OF GROUPS OF KEYS (Master and Slave)

If all the 24 or 25 keys scanned by a particular switch module fail to operate then the fault lies either in that module (check the voltages on both buss bars) or in the path from it to the analog key data multiplexor in the Keyboard Controller (incuding the cable). The source of such a fault may be isolated by swapping around the flat cable connectors to the switch modules.

Failure of certain keys belonging to each module is most likely to be caused by incorrect scanning addresses arriving at the switch module: either a cable fault or an I/O problem on the keyboard controller. In this case it is unlikely that the keypad or display will work either.

If no such module-related pattern to the faulty keys exists, then the problem is mechanical. Check that all spring contacts bend across the -5V buss bar by approximately 20 degrees from the horizontal when the keys are released and across the +5V bar by the same angle (in the opposite direction) when the keys are depressed. A tension spring in the back of each key returns it to the original position when it is released.

3.4 SLAVE KEYBOARD MALFUNCTIONS

Failure of groups of keys or individual keys on the slave keyboard can be diagnosed following the same guidelines as for the master keyboard. However two additional possible sources of faults exist: the cable from the master keyboard to the slave, and the CMI-14 slave interface. Since the slave scan address lines are the same as the master scan address lines, faults in the slave keyboard which corrupt those lines can cause the master to malfunction. Section 7.1.1 describes the use of the 4-pole DIL switch on the CMI-14 to disable individual switch module outputs when isolating slave keyboard faults. Ensure that all switches are open to enable the full keyboard velocity sensing prior to reassembling the slave.

CAUTION: Always turn off CMI power to the master keyboard before connecting or disconnecting the external cable between the master and slave. Omission to do this will cause damage to the switch modules in the slave keyboard.

The function of the CMI-10 Master Keyboard Controller card is to execute all keyboard facilities of the CMI and communicate the status of those facilities through a single serial link to the central processor. The facilities are -

Master keyboard scanning (with CMI-11 multiplexor).
Slave keyboard scanning (with CMI-14 slave interface and CMI-11 multiplexor).
Data link to CMI for the alpha-numeric keyboard.
Master keyboard keypad.
Keypad display of information from CMI.
Three slider pots.
Two on/off switches.
Three pedal controls with switches.

This section describes the operation of the CMI-10 board.

4.1 MPU,DECODING,RAM AND RESTART.

(Refer to drawing CMI10-00)

4.1.1 Microprocessor Unit

The central driver of the Keyboard Controller is the 6802 microprocessor unit (MPU) at location E567 which is activated by a 4MHz crystal. At power-up the MPU reset line is held low for approximately 0.4 seconds at which time it is released to begin execution. It is important that this restart time is less than the CMI's Central Processor restart interval to ensure that no characters sent to the Keyboard Controller are lost. The MPU may also reset manually by depressing SW1 (nearer the heatsink). This switch is debounced through the pair of open-collector NAND gates D12.

While the restart line is held low, the MPU places FFFE (hex) on the address buss and its first operation is to fetch the restart vector from locations FFFE/F. Execution is then transferred to the initialization routines in ROM. Successful completion of this power up phase is indicated by the keyboard switch lamps switching on for about one second, off for another second, then on again. A " - POWER ON - " message is then written to the keypad display.

A 4-pole dual-in-line (DIL) switch, SW3, is used to select the source of Non-Maskable Interrupts to the MPU. This may be either from the manual switch SW2 or a clocked timing signal. The DIL switch functions as follows:

Switch	Effect if closed
1	Select BRCK signal from Baud rate gen. as timing reference.
2	Select ø2 from MPU as timing reference.
3	Select SW2 as NMI
4	Select timing rerence as NMI

Clearly, switches 1 and 2 are mutually exclusive and must not be closed simulataneously, as are switches 3 and 4. Before feeding to switch 4, the high frequency reference selected by switches 1 or 2 is divided by 512, 1024, 2048 or 4096 by the binary counter C5. This division ratio is determined by the p.c.b. link next to C5 (normally 2048). The divided reference (signal SCND) is used as a control line signal to the PIAs, in addition to optioning as an NMI source.

With "KBDIOA" and "VELKEYD" ROMs, switches 2 and 3 only should be closed. This selects SW2 as NMI source, and has the same effect as restart SW1 except that NMI vector FFFC/D is used. Switch 1 of the DIL switch is nearest the edge of the p.c.b. with the heatsink.

The 6802 MPU contains 128 bytes of internal RAM. This is permanently enabled by tying the Ram Enable signal (pin 36) high.

4.1.2 Address Decoding

Selection of all ROMS, external RAM and peripheral devices is performed by four LS139 1-of-4 decoders in ICs E12 and E34. Addresses are decoded when both the ø2 and VMA (Valid Memory Address) signals from the MPU are high.

The address map of the Keyboard Controller is as follows:

Address (Hex)	Function
0 - 7F	Internal RAM. 23 bytes only used, for software variable storage.
80 - 83	Active key input/AD conv. input PIA (K34)
90 - 93	Key address output PIA (F34)
A0 - A1	Alpha-numeric keyboard comms. ACIA (C67)
B0 - B1	CMI communications ACIA (D67)
C0	Software readable switch
4000 - 43FF	External RAM #1 (L67, N67)
5000 - 53FF	External RAM #2 (K67, M67, not normally installed)
9000 - 9400	ROM #1 (J67, not normally installed)
A000 - A400	ROM #2 (HI67, not normally installed)
B000 - B400	ROM #3 (G67, "VELKEYD")
FC00 - FFFF	ROM #4 (F67, "KBDIOA")

4.1.3 Software Readable Switch

The six-pole dual-in-line (DIL) switch SW4 provides adjustment to the sensitivity of the analog controls. It is read whenever an A/D conversion detects a changed analog level. Bits 4 and 5 (switches 1 and 2, nearest the heatsink) are ignored and the 4-bit number remaining gives the minimum change in the converted level required before the change will be reported to the CMI.

The switch is read through buffer N8 whose inputs are pulled high, unless grounded by a closed switch. Thus a binary '1' corresponds to an open switch.

Normally, sensitivity is set to 3 digital levels so switches 3 and 4 only are closed.

4.1.4 External RAM

Provision is made on the CMI-10 p.c.b. for 2K of static RAM but normally only 1K is installed: 2114s L67 and N67. Each chip contains 1K x 4 bits storage. The upper nybble is stored in L67, and the lower nybble in N67.

4.2 ROMs and PERIPHERALS
(Refer to Drawing CMI10-01)

4.2.1 ROMs

Provision is made on the CMI-10 printed circuit board for four 2708 ROMs. Normally only two of these are installed: "KBDIOA" at location F67, and "VELKEYD" at G67. The first ROM contains the initialization and I/O firmware for the Keyboard Controller and the second contains firmware responsible for scanning the velocity sensitive keyboard and analog and switch controls.

4.2.2 Serial Communications ACIAs

Serial communication with the Alpha-numeric keyboard is accomplished through the 6850 Asynchronous Communications Interface Adaptor (ACIA) at C67, while communication with the CMI utilises the 6850 ACIA at D67. The Baud rate for both ACIAs is derived from the Baud rate generator at B12 driven by a 1.8432 MHz crystal and a p.c.b. link at C12 normally selects 9600 Baud operation (pin 1 of B12). The Baud rate generator also provides the BRCK signal, normally linked to 1200 Baud at B45.

Both ACIAs are normally linked via LK1 and LK2 to the common interrupt request (IRQ) buss signal. D67 generates IRQs when transmitting to and receiving from the CMI, while C67 generates IRQs when receiving from the Alpha-numeric keyboard.

4.2.3 Peripheral Interface Adapters (PIAs)

Two PIAs are used, each containing two 8-bit parallel I/O ports and four control outputs/IRQ input lines. The PIAs are configured during initialization and used as follows:

PIA F34

I/O port A PA0 - PA1	Peripheral address outputs. Buffered through G23 to address to provide: CMI-11 switch module addresses CMI-12 keypad mutiplexor addresses LED display module data Data inputs to flip-flops (G4) which switch control button lamps. Analog control input multiplexor addresses.
CA1	Scan Not Done (SCND) timing flag input
CA2	Strobe output to update lamp flip-flops
I/O port B PB0 - PB1 PB2 - PB7	LED display digit select lines LED display all-segments-on (CU) and module select (CS) signals.
CB1	Input flag from keypad multiplexor. Does not generate IRQs.
CB2	Strobe output to update a LED display ($\overline{DWS}$)

PIA K34

I/O port A PA0 - PA5	Inputs from music key threshold comparators
PA6	Input from control switch multiplexor enabled by BKA7
PA7	Input from keypad multiplexor, also enabled by BKA7
CA1	Inverted timing reference input. Does not generate IRQs.
CA2	Threshold select output
I/O port B PB0 - PB7	Data inputs from A/D converter (ADC)
CB1	$\overline{DR}$ (Data Ready) flag from ADC
CB2	B/$\overline{C}$ (Begin Conversion) strobe to ADC

4. MASTER KEYBOARD CONTROLLER, CMI-10 (continued)

4.3 POWER SUPPLIES AND ANALOG INTERFACE SECTION
(Refer to drawing CMI-10-02)

4.3.1 Power Supplies

The Keyboard Controller receives +20V, -20V and +10V from the CMI through a 6-pin Utilux connector. Six on-board regulators are used to generate three independant +5V supplies, in addition to +12V, -12V and -5V supplies. These power the Controller itself plus the keypad display, slider and pedal pots and switches.

The supply designated "+5V" powers all circuitry on drawings CMI-10-00 and CMI10-10-01 except the ROMs, which are powered separately from "+RV". The analog multiplexors, A/D converter and RS-232 drivers on CMI-10-02 receive power from "+XV" and where necessary, the -5V supply.

"+XV" also leaves the Controller board to power the CMI-11 keyboard switch multiplexors, and the keypad display.

4.3.2 Threshold Detection

MD1-3 and SD1-3 are the multiplexed signals representing the position of music keys addressed by the three master keyboard CMI-11 modules and the slave keyboard interface CMI-14, respectively. These signals are compared by the six MLM311s to a known threshold to determine when a key begins to be pressed, and when it is fully depressed.

The THLD signal from PIA K34 sets up one of two thresholds through the 741SC level shifter. If THLD is low, a -2.7V threshold is applied to the comparators. With THLD high, the threshold is +2.3V.

Initially, THLD is low. An unpressed key rests against the -5V buss bar so the corresponding comparator output will be high. When the key is first depressed and the spring contact leaves the -5V buss bar, the output of the module when that key is selected is pulled to just below zero volts by a 10k resistor to ground on the switch module and a 100k resistor to -5V on each comparator input. This causes the comparator to change state to a low. The change is read from the PIA whereupon THLD is switched high to select the +2.3V threshold, setting the comparator high again. It will return low when the key reaches the +5V buss bar at its full depression. The time taken between the two falling edges of the comparator output is noted by the MPU, and this mechanism forms the basis of the velocity sensitive keyboard.

The key continues to be compared to the +2.3V threshold until its release is detected.

4.3.3 Control Signal Multiplexors and A/D Convertor

User control signals enter the Keyboard Controller from several possible sources: two control panel switches, three pedal switches, three control panel slider pots and three pedal pots. The switch controls are analog multiplexed by H3 and read directly as KD6 when gated by a high level on BKA7.

The analog controls (slider and pedal pots) are multiplexed by I3, buffered by 741SC I4, and fed to the AD570 A/D converter at J4. The low frequency signals used do not require a sample and hold. The converter is strobed to begin a conversion by the B/C signal from the CB2 output of PIA K34 and flags the end of conversion to CB1 of the same PIA.

The sensitivity of the analog controls may be set by DIL switch SW4. Refer to section 4.1.3 for further details.

4.3.4 RS-232 Interface

ICs A5 and A6 are the RS-232 drivers for the two ACIAs described in section 4.2.2.

4.3.5 Lamp driver

The control panel lamps are supplied with 20V and switched on when the MC75452 driver at J2 pulls the appropriate line to ground. The driver is activated by signals LP1 and LP2 latched from PIA F34.

4.3.6 Connections

The Keyboard Controller requires four external connections as follows:

SO1 50-Way flat cable connector.

Pins	
1-5	Master switch module 1 scan address
6	N/C
7	-5V to Master switch module 1
8	"+XV" 5V to module 1
9	Ground to module 1
10	MD1 module 1 multiplexed output
11-20	Master switch module 2 connections as for 1
21-30	Master switch module 3 connections as for 1
31-37	Scan address to keypad and data lines to LED display
38	All segments on, display module 0 (CU)
39	Module select, module 0 (CS)
40-41	CU and CS lines, display module 1
42-43	CU and CS lines, display module 2
44-45	LED display digit select
46	Digit write strobe
47	Keypad multiplexed output
48	$\overline{\text{BKA3}}$, selects keypad multiplexor 2
49	Ground to display/keypad
50	"+XV" +5V to display/keypad

4. MASTER KEYBOARD CONTROLLER, CMI-10 (continued)

S02 10-Way rainbow cable connector

Pins		
	1-2	Button lamps switched returns
	3	Switch 2 (momentary on)
	4	Switch 1 (push on/push off)
	5	Slider pot 3 wiper
	6	+20V to lamps
	7	-5V to pots
	8	"+XV" +5V to pots
	9	Slider pot 2 wiper
	10	Slider pot 1 wiper

S03 26-Way rainbow cable connector

Pins		
	1	Pedal 1 pot wiper
	2	Pedal 1 switch
	3	Pedal 2 pot wiper
	4	Pedal 2 switch
	5	Pedal 3 pot wiper
	6	Pedal 3 switch
	7-11	Slave keyboard scan address
	12	Slave keyboard ground
	13-15	Slave switch module outputs
	16	RTS flag to alpha-numeric keyboard
	17	CTS flag to A/N keyboard
	18	A/N keyboard ground
	19	Data to A/N keyboard
	20	Data from A/N keyboard
	21	Ground
	22	CTS flag from CMI
	23	RTS flag to CMI
	24	Ground
	25	Data from CMI
	26	Data to CMI

S04 6-Way Utilux Connector

Pin		
	1	+10V return
	2	+10V
	3	+20V
	4	-20V
	5	Ground
	6	+/-20V return

4.4 SOFTWARE LOOP AND INTERRUPT ROUTINE

A useful clue when fault finding ROM-based equipment such as the CMI-10 is the main software loop which the processor normally executes in the "steady state": that state which exists after a successful power-on initialisation, but before any special functions have been called upon by key presses, changed A/D values, etc.
This software loop may also be referred to as the "idle loop". Knowledge of what happens in the idle loop allows a service person to establish, for example what peripherials are not being regularly accessed as they should.

The program flow of the idle loop in "VELKEYD" is as follows:

```
begin loop

    for keyselect = 1 to 32

       read key-pressed pattern from comparators

       for module select = 1 to 6 (3 master, 3 slave)

           update statuses in RAM of keys pressed

       end for

    end for

    read one of the control functions and update status
    (slider pots, pedal pots and switches)

    scan entire keypad for a keystroke

    wait for rising edge of SCND flag

end loop
```

The key scan loop executes 32 times because there are 5 key select lines but there are only 24 or 25 keys on each module so some iterations of the inner loop do not correspond to any real key. A different control function is monitored and updated on each iteration of the main loop.

A knowledge of the sources of interrupts and the functions performed in the interrupt service routine(s) can be similarly useful when fault tracing. In the KBDIOA firmware, there are three possible sources of interrupts (IRQ's):

1. A character has been received from the CMI.
2. A character previously transmitted to the CMI has completed transmission from the ACIA.
3. A character has been received from the alpha-numeric keyboard.

Characters received from the CMI are written to the LED display immediately. A transmit-complete interrupt causes the processor to check the output character queue and send another character if it is not empty. A character received from the alpha-numeric keyboard is placed on the output character queue unless the received character is actually a BREAK level, in which case a BREAK level is transmitted to the CMI.

The short piece of code which places characters on the output queue (and enables the transmitter interrupt) is actually a software interrupt routine, called by the SWI instruction rather than a subroutine call.

Three Keyboard Switch Modules are installed in each master and slave keyboard used with a CMI. Each module provides a single signal out which represents the state (pressed, released, or in flight) of one of the 24 or 25 keys addressed by the multiplexor inputs. This section describes the operation of the CMI-11.

5.1 KEYBOARD SWITCH MODULE OPERATION
(Refer to drawing CMI-11-01)

Five key address bits are provided provided by the Keyboard Controller CMI-10 as inputs to the CMI-11. The lower three of these are bussed across three 4051 analog multiplexors (ICs 2-4) so that each 4051 selects one of eight spring key contacts as its analog input. Normally, a key rests against a -5V buss bar, but when fully depressed, it contacts a +5V buss bar. In between, it contacts neither.

The outputs of ICs 2-4 are fed to another multiplexor, IC1, whose select inputs are the upper two bits of the key address. Thus the output of IC1 may be any of the 24 key contacts accessed by ICs 2-4. It may alternatively be the 25th key contact which is fed directly to IC1 as a fourth analog input.

Each CMI keyboard has a total of 49 keys so the 25th key is only used on the extreme right hand switch module. Provision is made on the switch module p.c.b. for a 10k resistor (R1) pulling to ground. This is to ensure that if the 25th key is not installed, it appears to the multiplexor as a key which is never pressed. However, the resistor must be removed if the 25th key is installed or the velocity sensing mechanism will not work on that key.
The output of IC1 is fed directly to the Keyboard Controller in a master keyboard or to the Slave Interface in a slave keyboard. Its unused inputs are grounded.

5.2 EXTERNAL CONNECTIONS

SO1 10-Way flat cable

Pins	1-5	Key scan address inputs
	6	N/C
	7	-5V supply
	8	+5V supply
	9	Ground
	10	Multiplexed analog output

6. KEYBOARD DISPLAY AND KEYPAD MODULE, CMI-12

The Display and Keypad Module provides a simple user interface with the CMI from the master music keyboard. A 16-switch keypad is scanned by the Keyboard Controller for commands to be sent to the CMI and a 12 digit LED display receives simple messages from the CMI to the user. This section describes the operation of the CMI-12.

6.1 DISPLAY AND KEYPAD OPERTION
(Refer to drawing CMI-12-01)

6.1.1 LED Display

The DL-1416 LED display modules, containing four digits each, accept 7 bit ASCII codes from the data lines to display the desired character. The key scan addresses are used as data inputs. Data is latched into the modules whose chip select line ($\overline{CS}$) is low on the falling edge of $\overline{DWS}$. The DA lines select which digit within the selected module(s) is written to. The $\overline{CU}$ line is a test enable line which causes every segment in each digit to light up.

6.1.2 Keypad

The keypad is simply an array of 16 momentary switches which connect to the common (+5V) line when pressed. Two 4051 1-of-8 analog multiplexors scan the keypad. Their select and inhibit inputs are taken from the key scan address lines. Only enabling one multiplexor at a time allows the outputs to be wired together on the same KPAD signal.

6.2 EXTERNAL CONNECTIONS

SO1 20-Way Ribbon cable connector

Pins	1-2	Digit select
	3,5,7	Display module select
	4,6,8	Display module test (all segments on)
	10	Digit write strobe
	9,18, 11-16	Key scan address and data to display modules
	17	Keypad multiplexed output
	19	Ground
	20	"+XV" +5V supply

The Slave Keyboard Interface provides regulated power supplies to the CMI-11 switch modules in a slave keyboard and buffers the analog outputs of the switch modules before feeding them to the master keyboard controller. This section describes the operation of the CMI-14.

7.1 OPERATION

(Refer to drawing CMI-14)

7.1.1 Scanning and Buffering

The five slave key scan address lines from the master keyboard controller are fed straight through to the CMI-11 switch modules. The output from each module is buffered by a 741SC in a non-inverting configuration and fed to the master controller. A 4-pole dual-in-line (DIL) switch allows the input of each buffer to be pulled to nearly -5V for testing purposes. In the event of a switch module being unplugged, closing the switch corresponding to that module simulates all keys released. Two or more floating buffer inputs result in the keyboard controller going into overflow due to sensing too many keys pressed. All switches should normally be open, otherwise the velocity sensing system will not work.

7.1.2 Power Supplies

The CMI-14 is supplied with +20V and -20V from the CMI via the master keyboard. A 4V7 zener is used on each supply side to provide +12V and -12V to the 741 buffers, and 7805 and 7905 regulators send +5V and -5V respectively to the switch multiplexors.

7.2 EXTERNAL CONNECTIONS

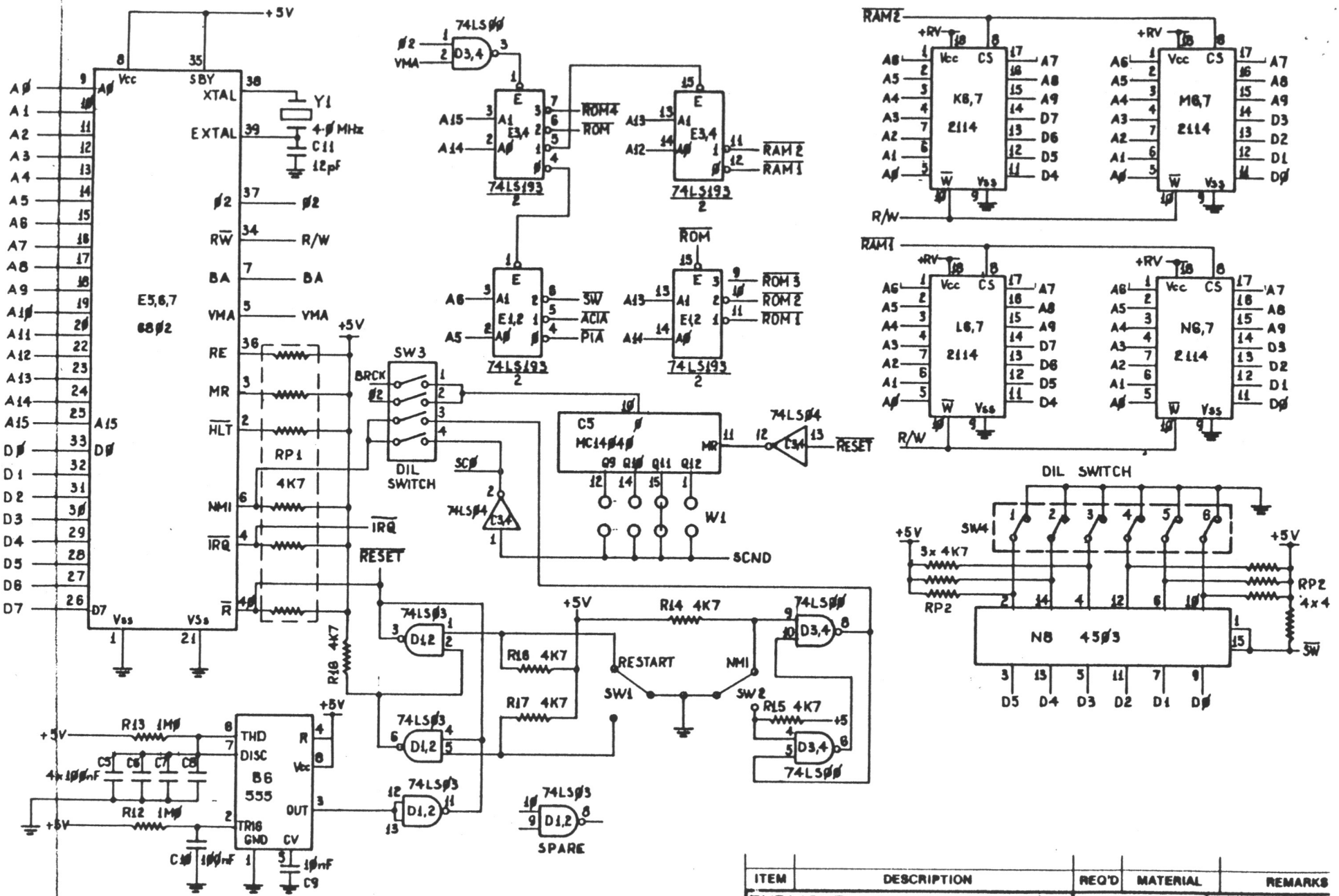
SO1 30-Way flat cable connector

Pins	1-5	Slave switch module 1 scan address
	6	N/C
	7	-5V to Slave switch module 1
	8	"+XV" 5V to module 1
	9	Ground to module 1
	10	MD1 module 1 multiplexed output
	11-20	Slave switch module 2 connections as for 1
	21-30	Slave switch module 3 connections as for 1

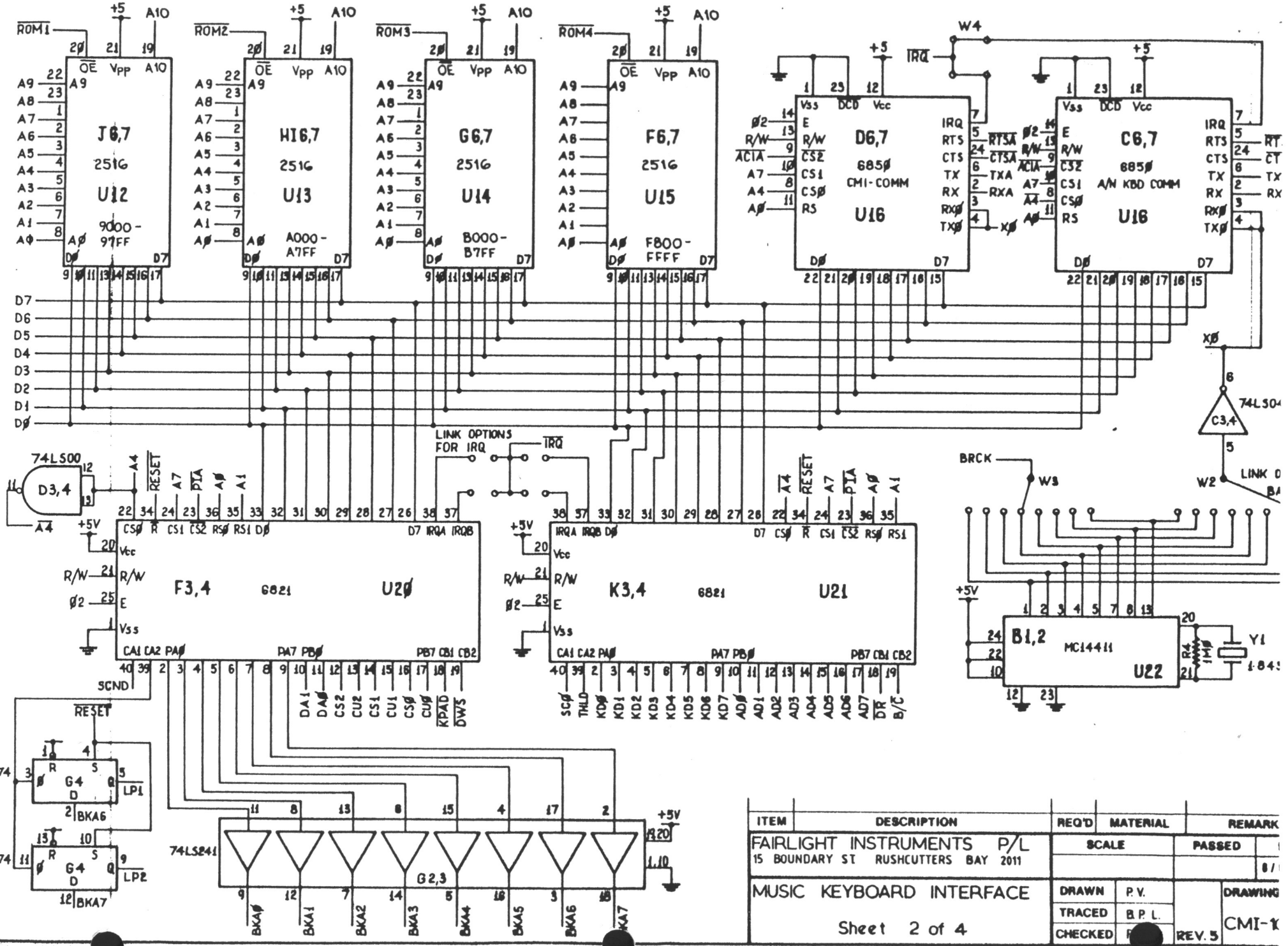
7. SLAVE KEYBOARD INTERFACE, CMI-14 (continued)

SO2 25-Way D series external connector

Pins		
	1-2	Ground
	3-7	Slave keyboard scan addresses
	8	Ground
	9-11	Slave multiplexor outputs
	12-21	N/C
	22-23	-20V supply
	24-25	+20V supply



ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARKS
FAIRLIGHT INSTRUMENTS P/L 15 BOUNDARY ST. RUSHCUTTERS BAY 2011 (02) 335222		SCALE	PASSED	D
			26/8/1982	6/8/
MUSIC KEYBOARD INTERFACE Sheet 1 of 4		DRAWN P.V. TRACED B.P.L. CHECKED P.	REVS	DRAWING CMI-10



ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARK
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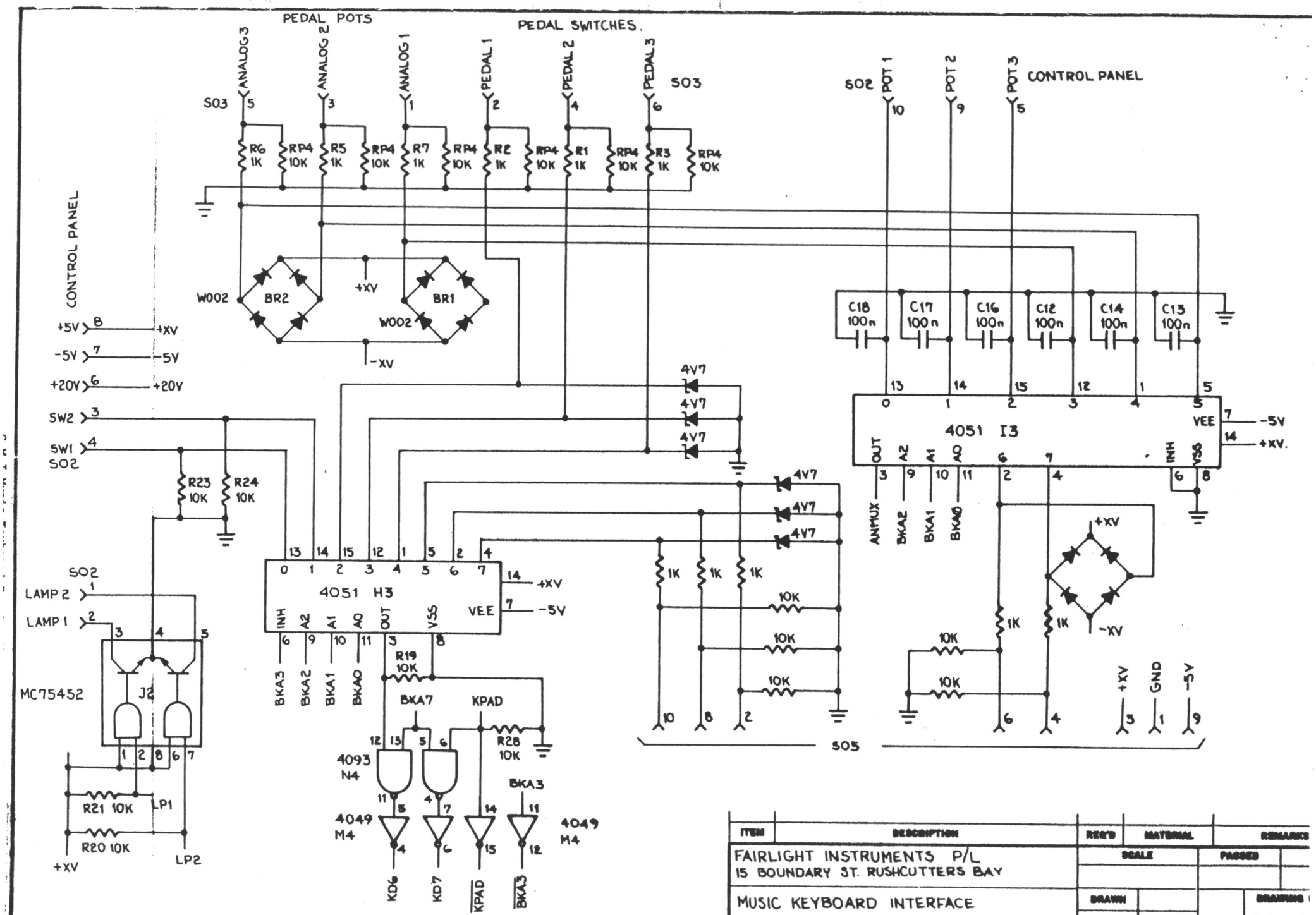
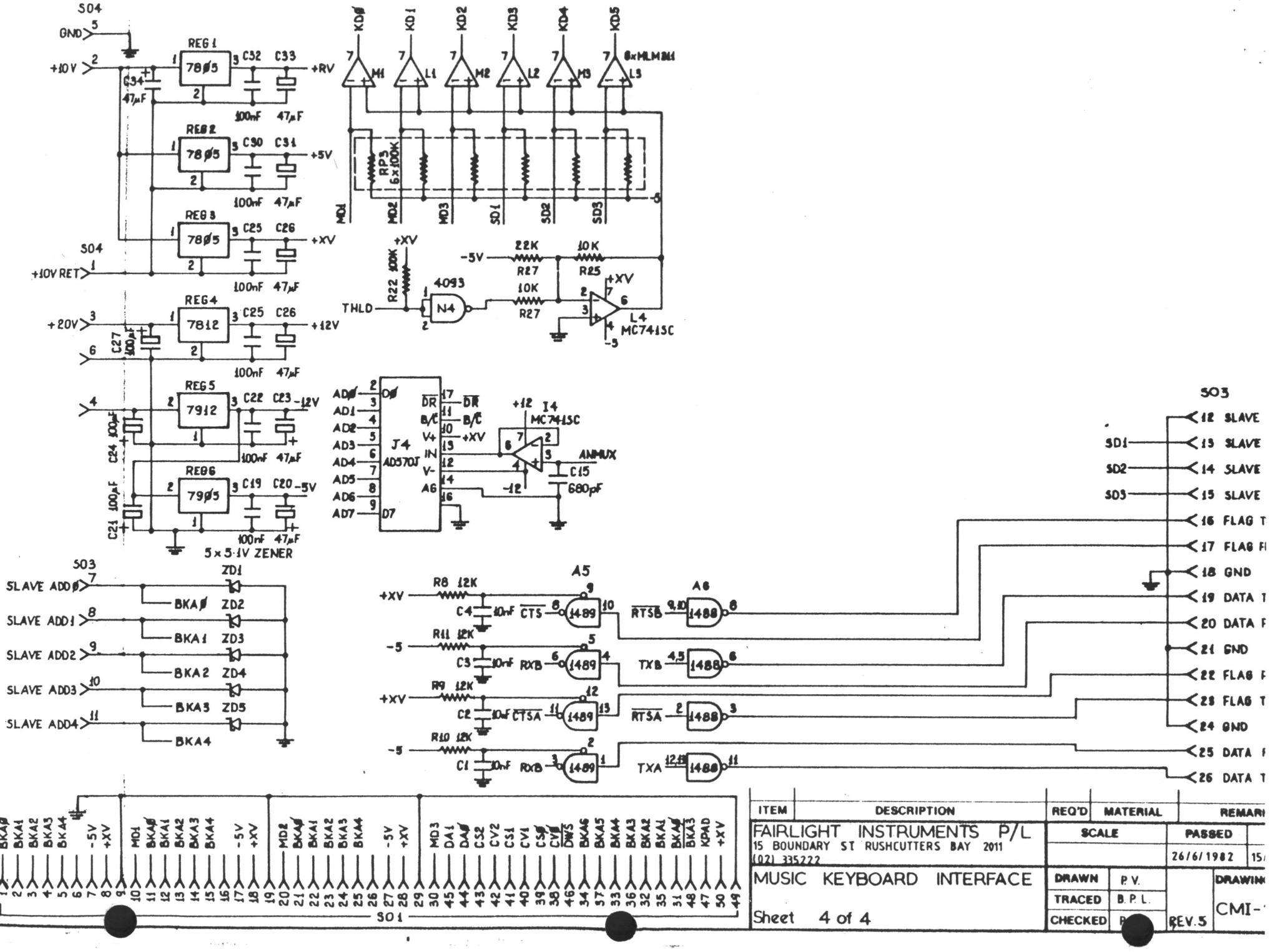
MUSIC KEYBOARD INTERFACE Sheet 2 of 4		DRAWN P.V. TRACED B.P.L. CHECKED		REV. 5

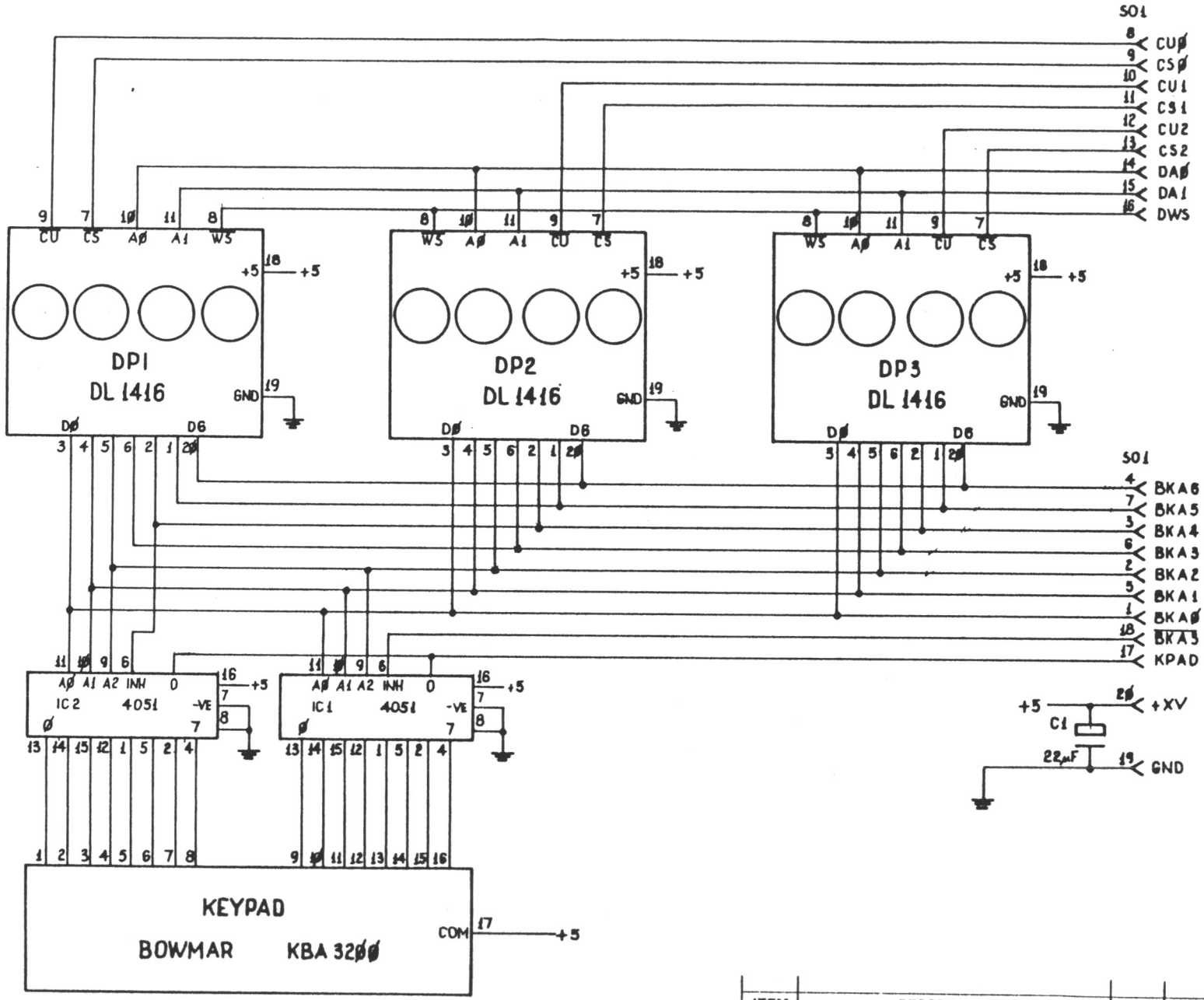


ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARKS
FAIRLIGHT INSTRUMENTS P/L 15 BOUNDARY ST. RUSHCUTTERS BAY		SCALE		PASSED
MUSIC KEYBOARD INTERFACE SHEET 3 of 4		DRAWN TRACED CHECKED		DRAWING CMI-10 REV 5

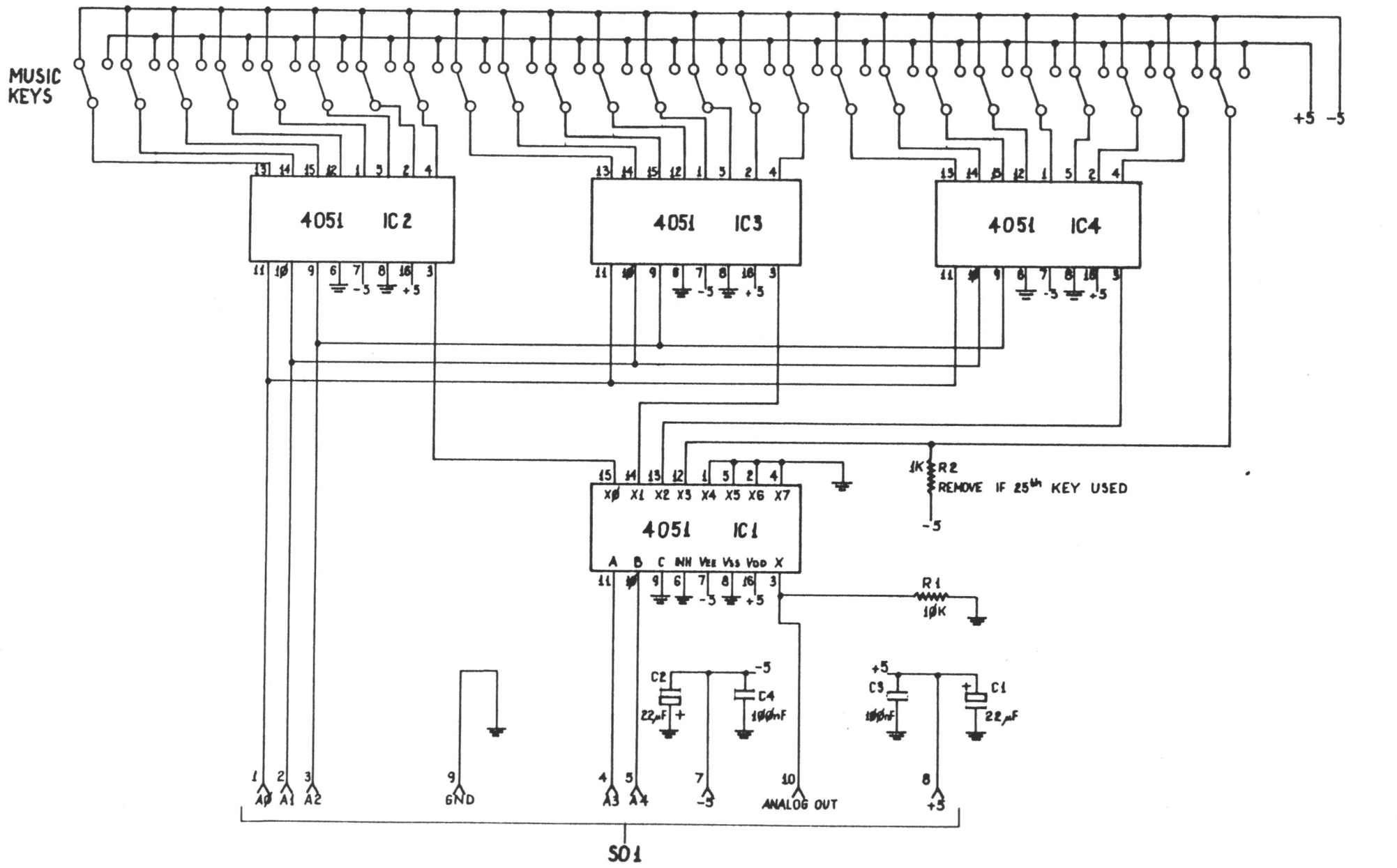
A3



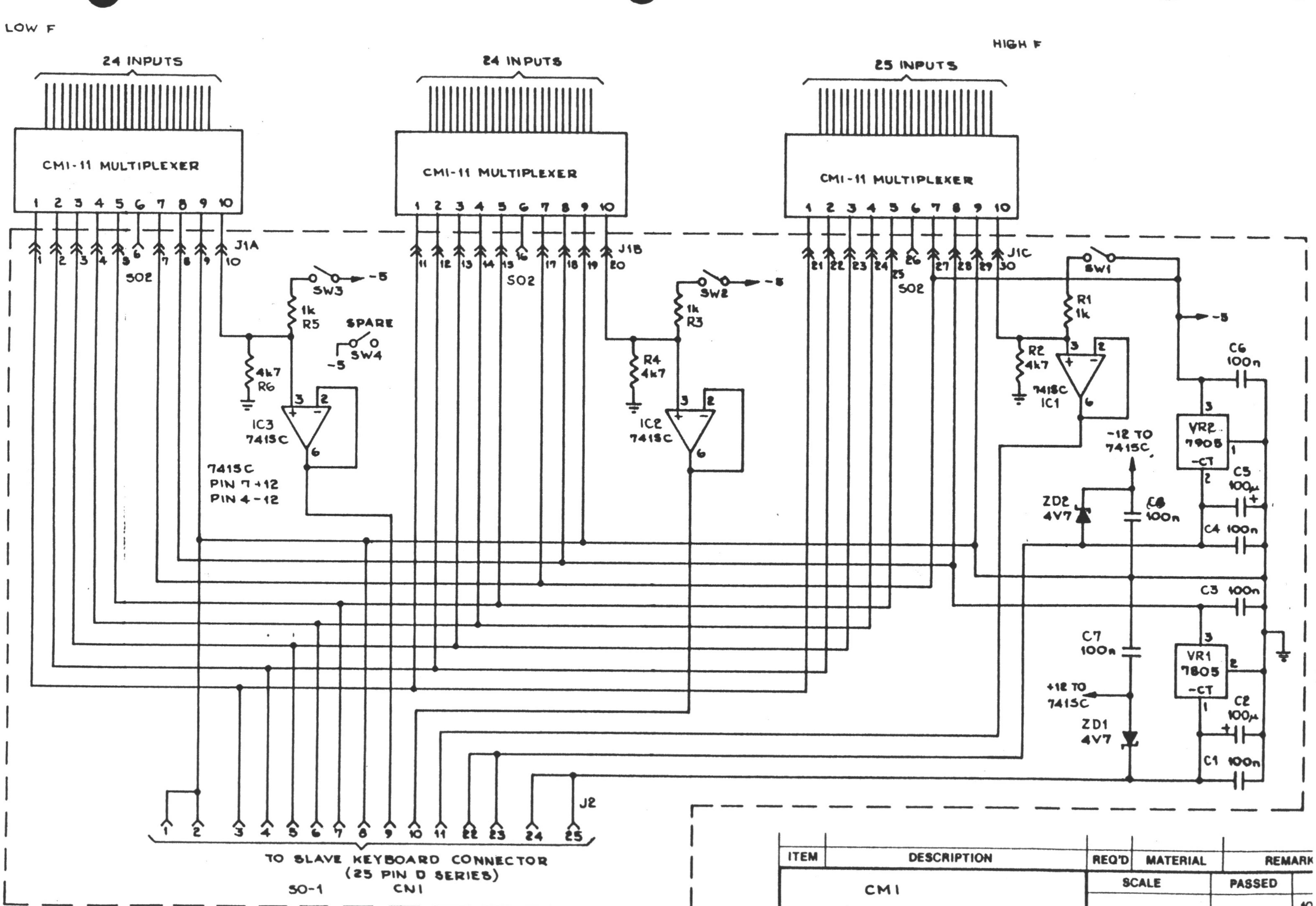
ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARK
FAIRLIGHT INSTRUMENTS P/L 15 BOUNDARY ST RUSHCUTTERS BAY 2011 (02) 335222		SCALE	PASSED	
			26/6/1982	15/
MUSIC KEYBOARD INTERFACE		DRAWN P.V.		DRAWING
		TRACED B.P.L.		
Sheet 4 of 4		CHECKED	REV.5	CMI-



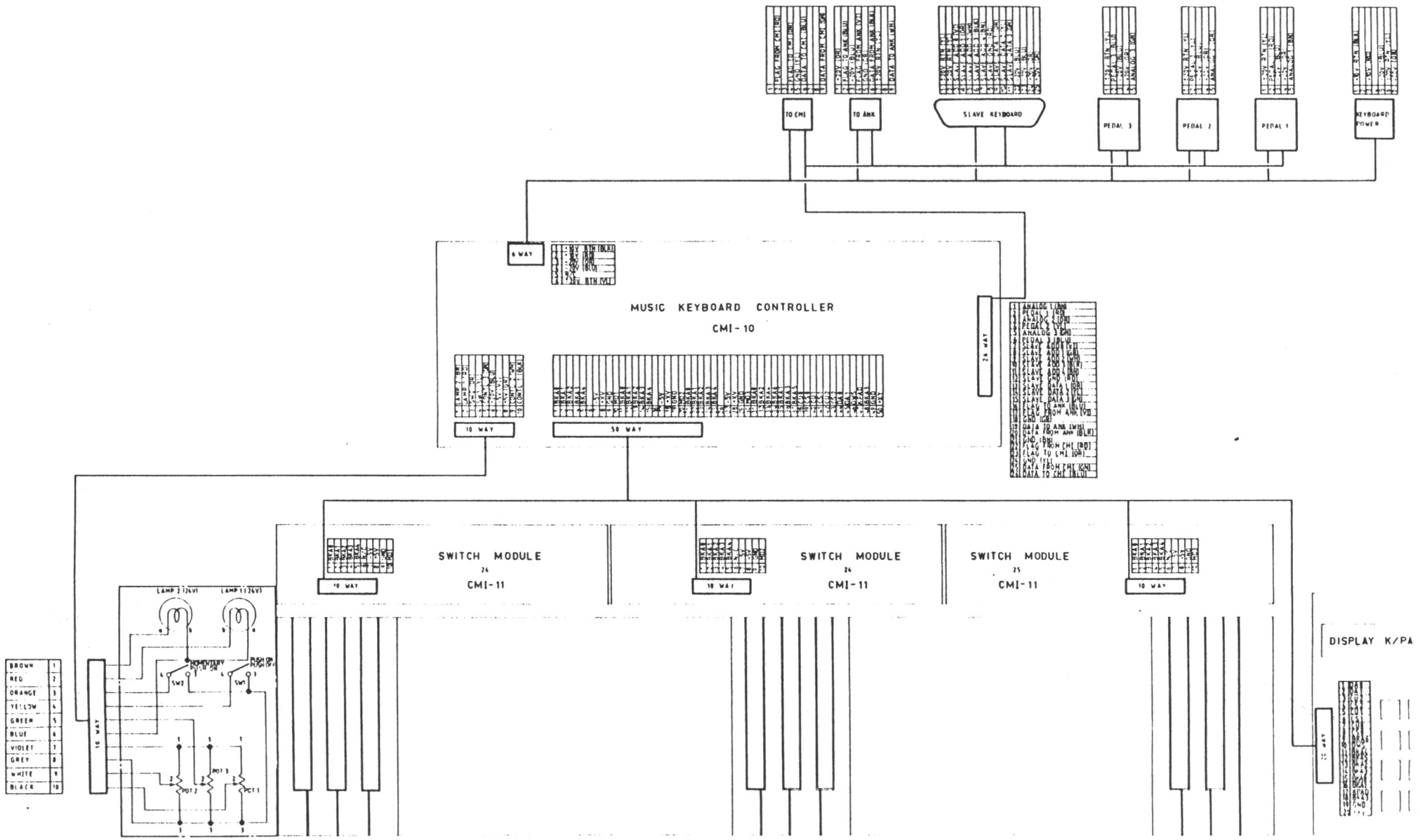
ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARKS
FAIRLIGHT INSTRUMENTS P/L 15 BOUNDARY ST. RUSHCUTTERS BAY 2011 (02) 335222		SCALE		PASSED 26/6/1982
KEYPAD / DISPLAY MODULE Sheet 1 of 1		DRAWN P.V. TRACED B.P.L. CHECKED P.V.		DRAWING CMI-1



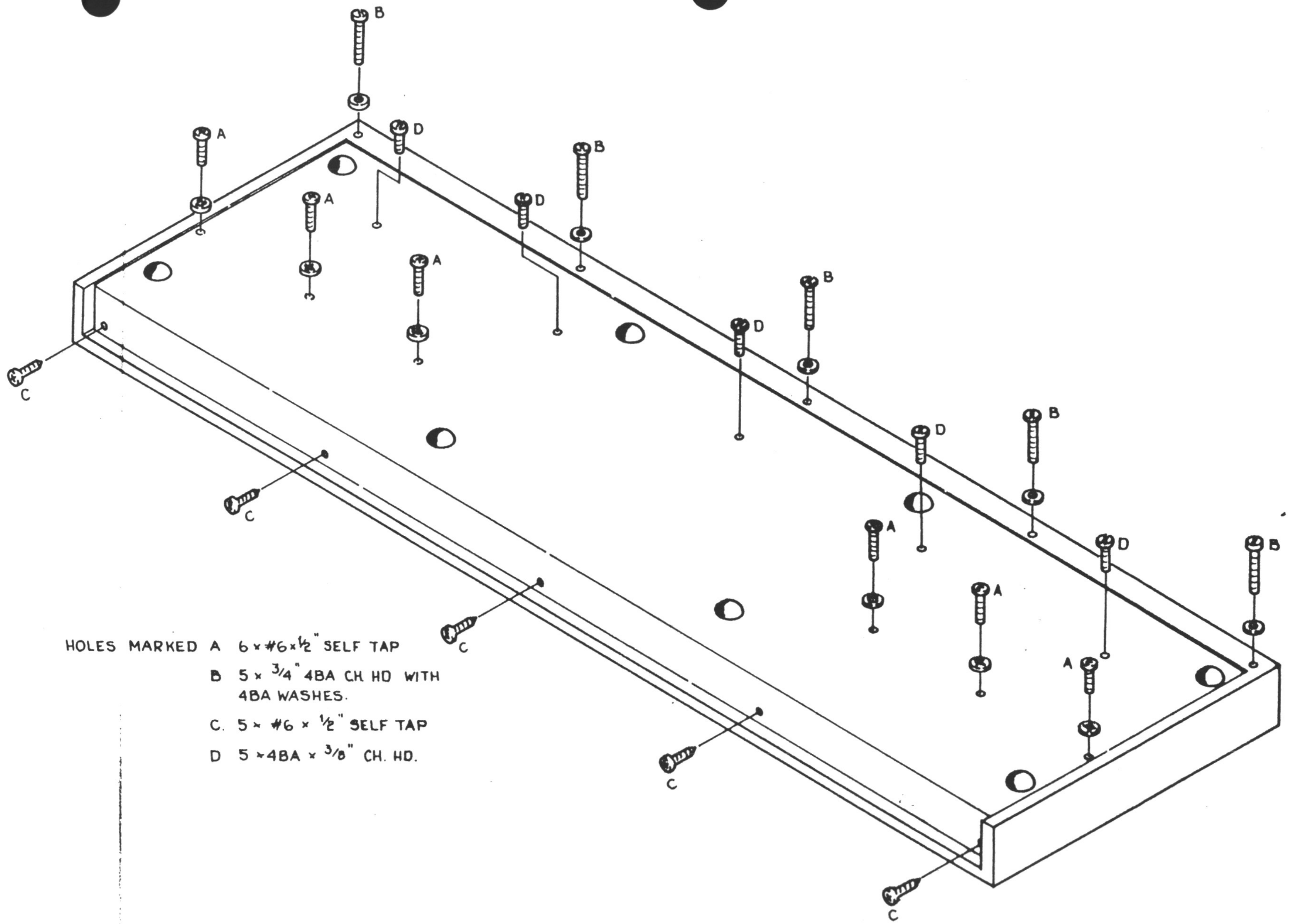
ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARKS
FAIRLIGHT INSTRUMENTS P/L 15 BOUNDARY ST. RUSHCUTTERS BAY 2011 (02) 335222		SCALE		PASSED 26/6/1982
KEYBOARD SWITCH MODULE REV. 3, 4 Sheet 1 of 1		DRAWN P.V. TRACED B.P.L. CHECKED P.V.		DRAWING CMI-11



ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARK
	CMI	SCALE		PASSED
				10
	SLAVE INTERFACE SHEET 1 of 1	DRAWN	PV	DRAWING
		TRACED	MTB	CMI-1
		CHECKED	PV	



ITEM	DESCRIPTION	REQ'D	MATERIAL
MASTER COPY	CMI MUSIC KEYBOARD	SCALE	
	SIGNAL & POWER WIRING DIAGRAM	DRAWN / TRACED / CHECKED	



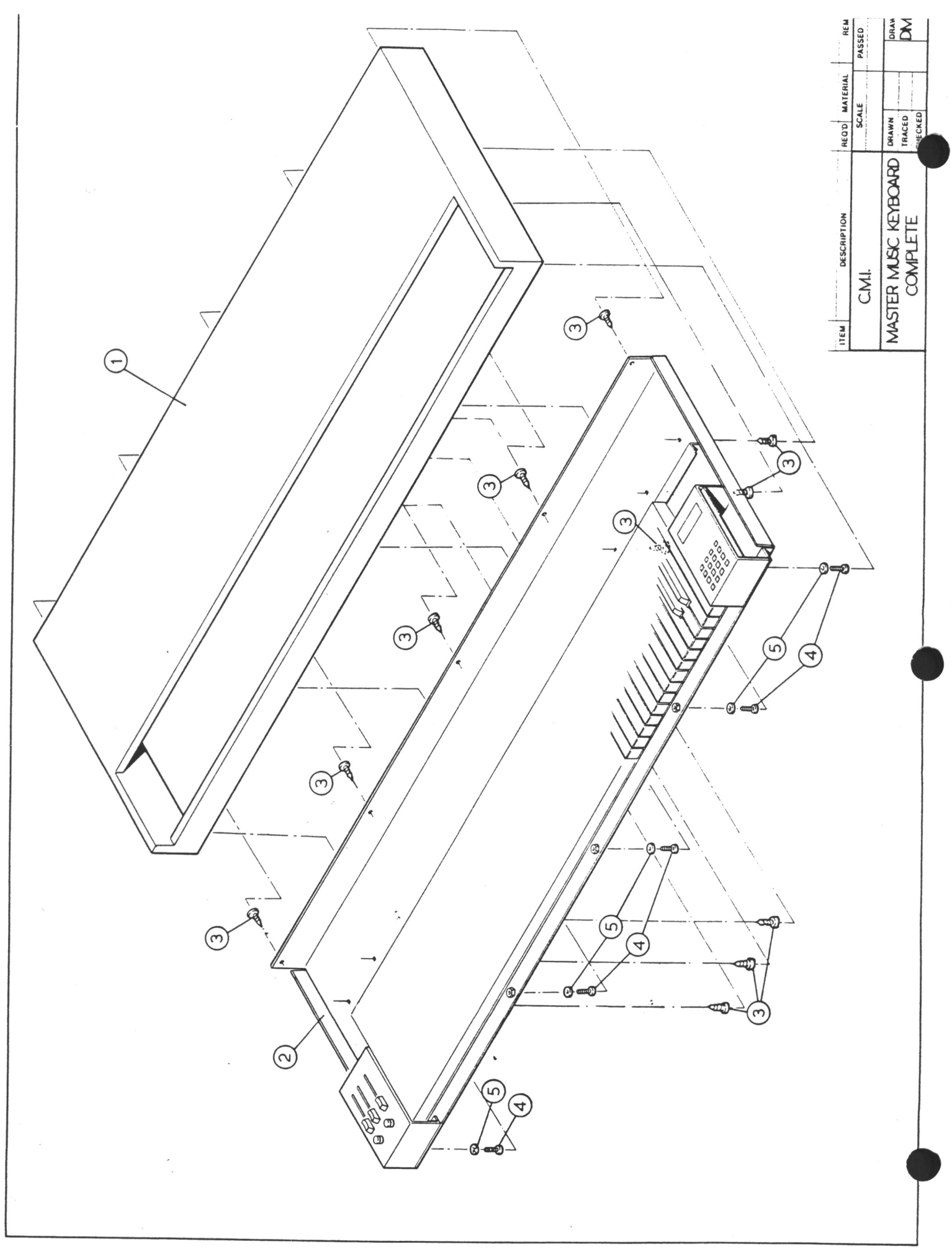
HOLES MARKED A 6 × #6 × 1/2" SELF TAP

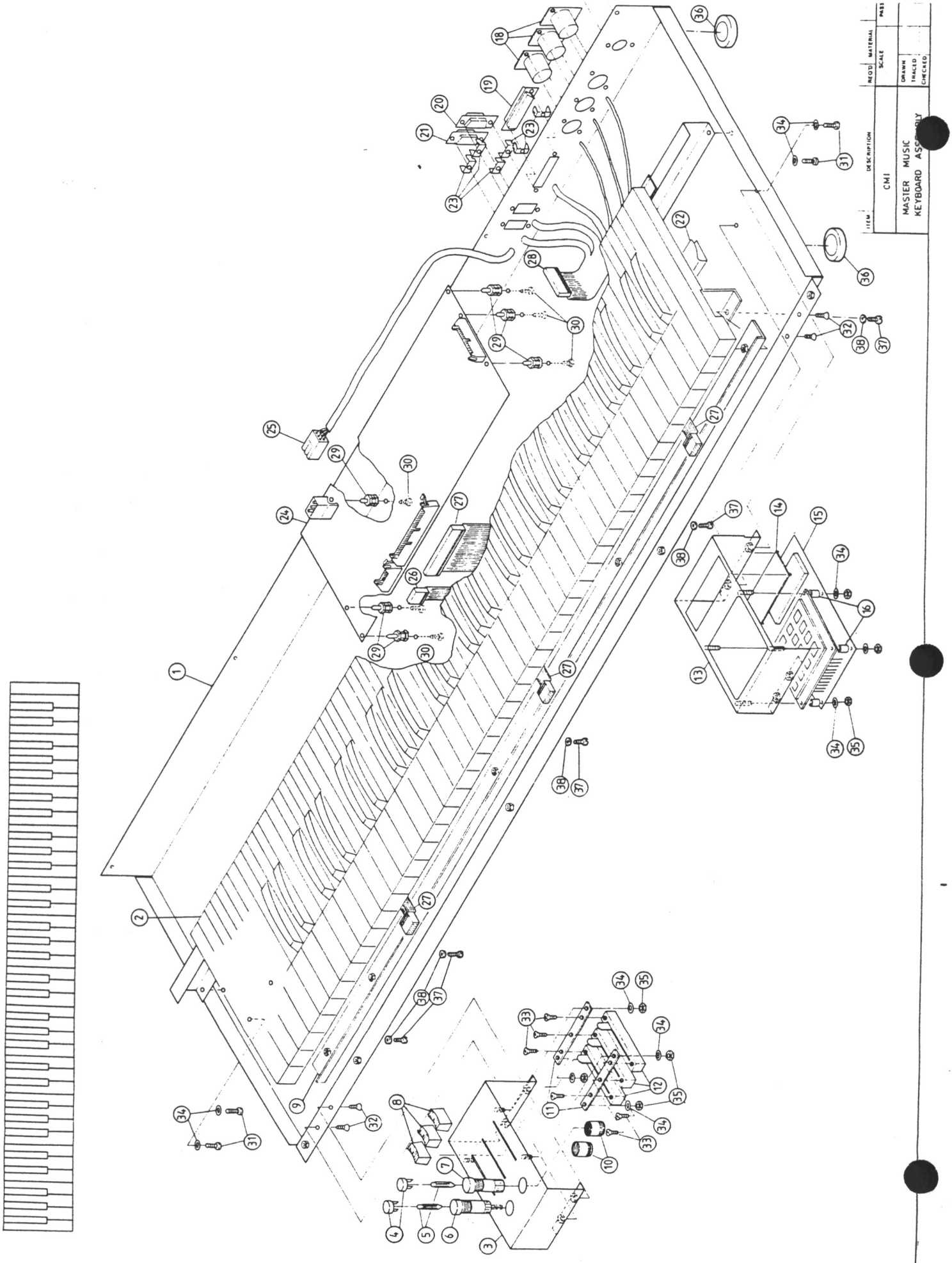
B 5 × 3/4" 4BA CH HD WITH 4BA WASHES.

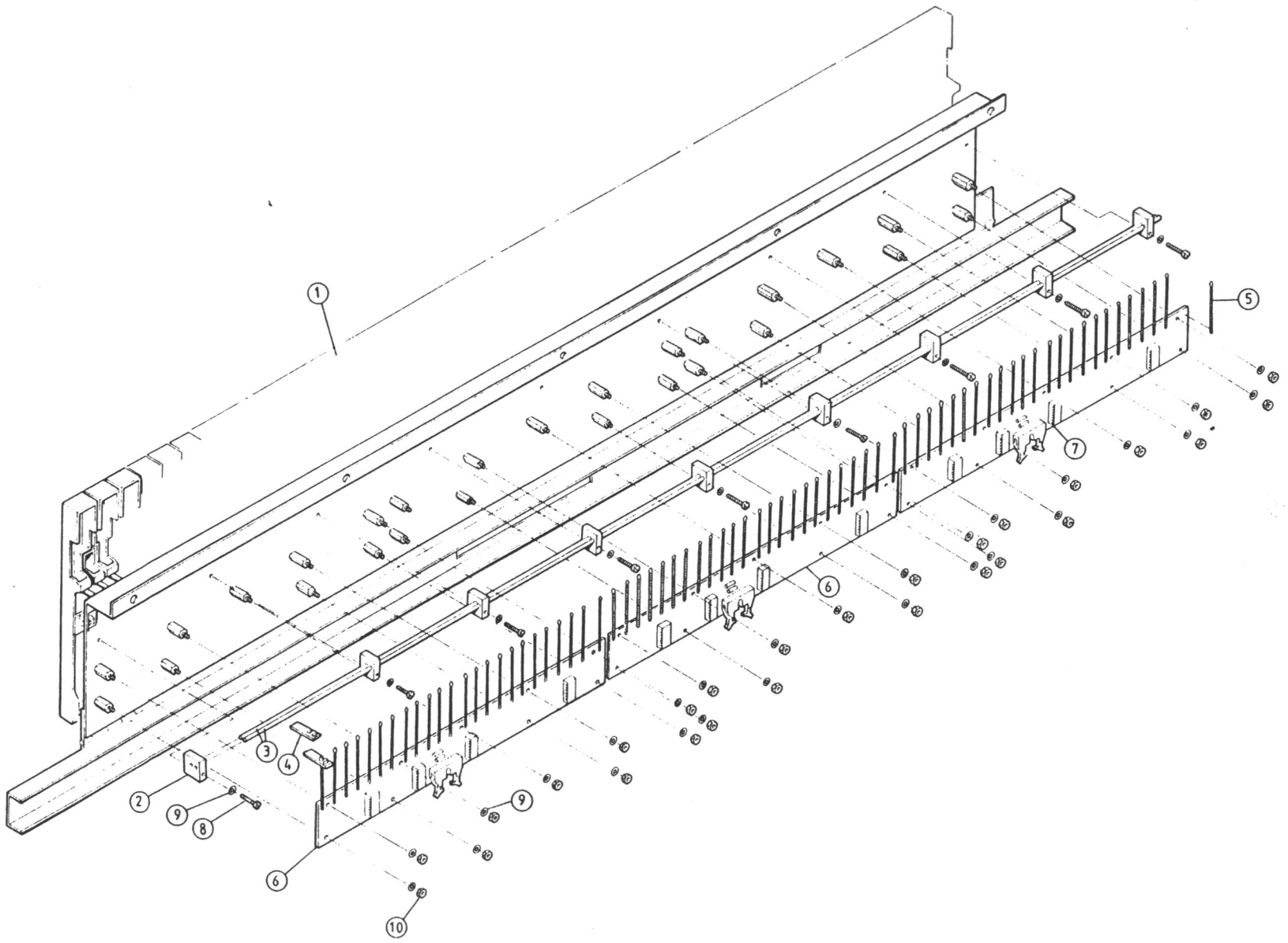
C. 5 × #6 × 1/2" SELF TAP

D 5 × 4BA × 3/8" CH. HD.

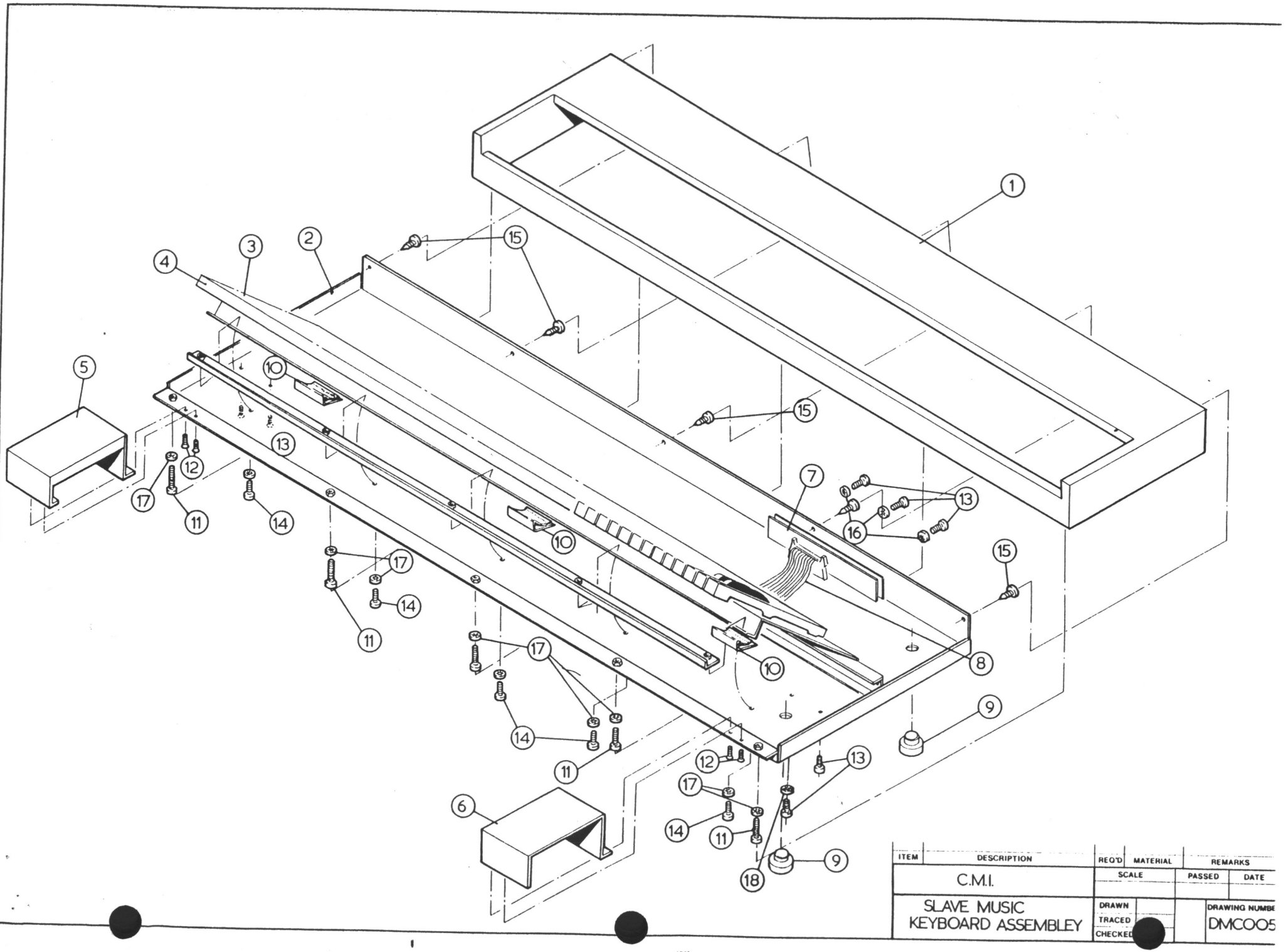
ITEM	DESCRIPTION	REQ'D	MATERIAL		REMARK
	C.M.I.	SCALE		PASSED	
					5
	EXPLODED VIEW OF FIXING SCREWS ON MASTER KEYBOARD TOP COVER	DRAWN	MTB		DRAWING
		TRACED			DMC(
		CHECKED	C.T.		


ITEM
DESCRIPTION
REQ'D
MATERIAL
REM
C.M.I.
SCALE
PASSED
MASTER MUSIC KEYBOARD
COMPLETE
DRAWN
TRACED
CHECKED
DRAW
DM
1
2
3
4
5


CMI
MASTER MUSIC KEYBOARD ASSEMBLY
DESCRIPTION
ITEM
REQD
MATERIAL
SCALE
DRAWN
TRACED
CHECKED
PASS



ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARK
	CMI		SCALE	PASSED
	MUSIC KEYBOARD SUBASSEMBLY		DRAWN / TRACED / CHECKED	DRAWING DMC



ITEM	DESCRIPTION	REQ'D	MATERIAL	REMARKS
	C.M.I.	SCALE		PASSED / DATE
	SLAVE MUSIC KEYBOARD ASSEMBLEY	DRAWN / TRACED / CHECKED		DRAWING NUMBE: DMC005

REF. NO	PART NO	DESCRIPTION	REMARKS

11.1 DMC004B MASTER KEYBOARD

1	G0028	COVER MUSIC WOOD	BEIGE
2	G0027	PANEL MUSIC BASE	BEIGE
3	H0114	SCREW 6GX1/2" PAN	
4	H0127	SCREW 4BAX3/4" CHD	
5	H0008	WASHER 4BA STAR	

11.2 DMC004 MASTER KEYBOARD ASSEMBLY

1	G0027	PANEL MUSIC K/BD BASE
2	MC015	KEYBOARD MECHAISM ASSY
3	G0023	CHEEK LH MASTER
4	G5406	BEZEL WHITE
5	G5407	LAMP
6	G5404	SWITCH #1
7	G5405	SWITCH #2
8	G5146	KNOB SLIDER POT
9	G0105	STRIP CLAMP MUSIC K/BD
10	H0211	NUT SWITCH
11	G0024	STRIP SLIDER POT
12	G5161	POT SLIDER
13	G0025	CHEEK RH MASTER
14	G5165	BEZEL DISPLAY RED
15	MCMI12	CARD MUSIC DISPLAY
16	G5142	SPACER 6BAX1/4" ROUND
17	D6738	CONNECTOR CANNON 7P
18	D6710	CONNECTOR CANNON 5S
19	D6729	CONNECTOR DMINI 25S
20	D6727	CONNECTOR DMINI 9S
21	D6728	CONNECTTOR DMINI 9P
22	G5122	CLIP CABLE
23	D6731	LUG DMINI
24	MCMI10	CARD C.M.I-10
25	G5219	CONNECTOR UTH9356-6R
26	MC070	CABLE SLIDER POT ASSY
27	MC063	CABLE KEYBOARD ASSY
28	MC071	CABLE REAR PANEL
29	G5107	STANDOFF
30	H0125	SCREW 6GX1/4" CHD
31	H0124	SCREW 6BAX1/4" CHD
32	H0117	SCREW 6BAX1/4" CSK
33	H0130	SCREW 6BAX3/16" CSK
34	H0012	WASHER 6BA STAR
35	H0201	NUT 6BA HEX
36	G5183	FOOT RUBBER
37	H0112	SCREW 4BAX3/8" CHD
38	H0008	WASHER 4BA STAR

11. MECHANICAL PARTS LIST (continued)

REF. NO	PART NO	DESCRIPTION	REMARKS

11.3 DMC015 MASTER/SLAVE KEYBOARD SUBASSEMBLY

1	G5156	KEYBOARD MUSIC 73 KEYS	
2	G5154	BRACKET A/N/ K/BD MTG	
3	G5153	BAR PLATED	
4	G5187	RETAINER SPRING MUSIC K/BD	
5	G5158	SPRING KEYBOARD MUSIC	
6	MCM11A	CARD K/BD MUSIC 24SW	
7	MCM11B	CARD K/BD MUSIC 25SW	
8	H0122	SCREW 6BAX3/4" CHD	
9	H0012	WASHER STAR 6BA	
10	H0201	NUT 6BA HEX	

11.4 DMC005 SLAVE KEYBOARD

1	G0030	COVER MUSIC SLAVE WOOD BEIGE	
2	G0029	PANEL MUSIC SLAVE BASE BEIGE	
3	G5156	KEYBOARD MUSIC 73 KEYS	
4	G0105	STRIP CLAMP MUSIC K/BD.	
5	G0002	CHEEK SLAVE LH B/K	
6	G0003	CHEEK SLAVE RH B/K	
7	MC014	SLAVE KEYBOARD INTERFACE CARD	
8	MC019	CABLE MUSIC SLAVE K/BD INTERNAL	
9	G5183	FOOT RUBBER	
10	G5122	CLIP CABLE	
11	H0122	SCREW 6BAX3/4" CHD	
12	H0117	SCREW 6BAX1/4" CSK	
13	H0124	SCREW 6BAX1/4" CHD	
14	H0112	SCREW 4BAX3/8" CHD	
15	H0114	SCREW SELF TAPPER NO6X1/2" SLOTTED PAN HEAD	
16	H0012	WASHER 6BA STAR	
17	H0007	WASHER 4BA FLAT	